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Tables for Predicting the Slash Weight of Shortleaf Pine

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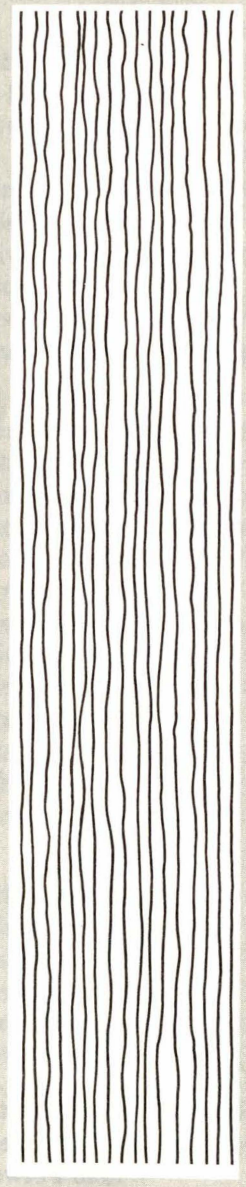

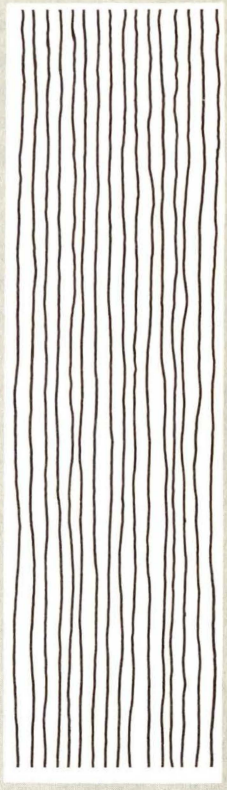

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TABLES FOR PREDICTING THE SLASH WEIGHT OF SHORTLEAF PINE

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Crown weight tables are used to provide estimates of slash loading that will result from timber cutting. This information is useful for assessing potential utilization of slash for fuelwood or other forest products, predicting fire behavior potential, estimating smoke emissions from prescribed fire, and guiding fuel management decisions.

Crown weight tables for shortleaf pine (*Pinus echinata* Mill.) are available from several sources (Clark and Taras 1976, Crosby and Loomis 1967, Johansen and Loomis 1981, and Loomis *et al.* 1966). Although these publications provide slash weight estimates, they do not provide the standard fuel size classes required in the Rothermel (1972) fire spread model used in the National Fuel Appraisal Process (Hirsch et al. 1981, Radloff *et al.* 1982).

The tables presented here provide slash weights and crown component fractions for shortleaf pine in the Missouri Ozarks. Weights are given for 3-inch and 4-inch merchantable tops. These tables supplement the publication "Handbook for Predicting Slash Weight of Trees in the Northeast" (Freeman *et al.* 1982).

BASIS FOR TABLES

Loomis *et al.* (1966) used diameter at breast height (d.b.h.) and crown ratio (the percent of total tree height occupied by live crown) to formulate an equation for estimating crown weight of shortleaf pine:

$$W = \frac{D^{1.736}R^{1.033}}{147.2} + \frac{D^{2.576}R^{1.458}}{1745.7} \qquad [1]$$

where:

W = dry weight of crowns (pounds),
D = d.b.h (inches), and
R = crown ratio (percent).

To construct tables 1 and 2, we added unmerchantable tip weights, corresponding to a 3-inch and a 4-inch merchantable top diameter, to the crown weight estimates from equation [1]. Weights of the 3- and 4-inch tips were estimated by using tip-weight data for ponderosa pine (Brown *et al.* 1977), assuming similar tip form and adjusting according to the relative wood densities for the two species. Shortleaf pine does have a sharper taper than ponderosa pine and would weigh somewhat less, but we considered this insignificant for the purposes of the tables.

Tables 3 and 4, which show the crown component fractions for standard fuel size classes, were constructed by using the branchwood and foliage weight tables given by Loomis *et al.* (1966). The tables give branchwood component weights for size classes of 0 to 0.5 inch, 0.6 to 1.5 inch, 1.6 to 3.0 inches, and greater than 3 inches. By adding tip weights to these tables and then using a Lagrange interpolation equation, crown component fractions were calculated for the standard branchwood fuel size classes of 0 to 1/4 inch, 1/4 to 1 inch, 1 to 3 inches, and more than 3 inches. These standard fuel size classes correspond to the 1-, 10-, 100-, and 1,000-hour timelag fuels described by Deeming *et al.* (1977).

Weights shown in table 1 for trees under 3 inches in diameter represent the total tree. Stem weights for these trees are based on an equation from Whittaker and Woodwell (1968). For users needing weight estimates for saplings, Edwards and McNab (1979) list equations for shortleaf pine and three other southern pines, using diameter at base of stem and total tree height as input variables.

USING THE TABLES

Crown Weight Tables

Recommended steps for using the crown weight tables are as follows:

Step 1.—Summarize the tree harvest data—numbers of trees to be cut per acre by d.b.h. class and crown ratio category. Always use a d.b.h. distribution rather than an average stand diameter. Using an average d.b.h. can result in a biased estimate because of nonlinear d.b.h.-weight relations.

Step 2.—Select the crown weight table appropriate for either a 3-inch (table 1) or 4-inch (table 2) top (weights based on a 2-inch top can be found in Clark and Taras (1976)), then (a) multiply the number of trees per acre to be harvested from each d.b.h. and crown ratio category by the table entry for that category; (b) sum the products over all categories to get the estimate of slash weight produced from the crowns of harvested trees; and (c) do the same with small diameter trees that have been trampled during logging, using the weights shown in table 1 for trees less than 3 inches in diameter.

Step 3.—Estimate slash weight in tons per acre for breakage and defect using the following equation (Brown *et al.* 1977):

$$W = \frac{(v) \times (f) \times (d)}{2000} \qquad [2]$$

where:

- W = the weight of debris from defect and breakage (tons per acre),
- v = merchantable volume to be cut (cubic feet per acre),
- f = fraction of merchantable volume to be left on the ground as defect and breakage, and
- d = density of wood (pounds per cubic foot).[1]

Step 4.—Summarize the total estimated weight of debris by adding:

a. Weight of crowns from cutting (step 2b).
b. Weight of trampling debris (step 2c).
c. Weight of defect (cull) and breakage material left in the woods after cutting (from step 3).
d. Weight of existing downed woody material from downed woody fuel inventory (Brown 1974).

[1]*The density of shortleaf pine is 31.8 pounds per cubic foot (U.S. Department of Agriculture 1974).*

This will give you the total predicted weight o debris remaining on the ground after cutting. Thi debris includes both slash from cutting and th material existing before cutting. These steps, as wel as the use of tables 3 and 4 to estimate slash weigh by fuel size classes, are illustrated in the followin example.

Example of Slash Prediction

Step 1.—This example involves a proposed thin ning operation with utilization of all stem material t a 4-inch top. Assume all cut trees in the stand have 50 percent crown ratio. Fifty stems per acre are to b cut from each of three d.b.h. classes—5-inch, 6-inch and 7-inch. Further assume there will be no tram pling damage and the preharvest fuel loading is tons per acre.

Step 2.—Using applicable weights (from table 2 the calculations are as follows:

D.b.h.	Trees/acre	Lbs/tree	Lbs/acre	Tons/acre
5	50	53	2,650	1.3
6	50	57	2,850	1.4
7	50	64	3,200	1.6
			8,700	4.3

Step 3.—In this example, assume the volume (v that will be removed is 670 cubic feet per acre. The wood density (d) of shortleaf pine is 31.8 pounds pe cubic foot. Breakage is judged to be 2 percent in this case and the defect left on the ground is estimated t be 3 percent. The fraction (f) of merchantable volume expected to be left on the site is 0.02 + 0.03 or 0.05. Substituting in equation [2] gives

$$W = \frac{670 \times 0.05 \times 31.8}{2000} = 0.53 \text{ tons per acre of defect}$$

Step 4.—The fuel residue can now be estimated:

a. Weight of crowns from cutting	= 4.3
b. Weight from trampling	= .0
c. Weight from defect and breakage	= .5
d. Existing downed woody material	= 3.0
Total	7.8

Thus, about 8 tons per acre of fuel residue will be on the site after thinning.

Fuel Size Components

Fuel size class component fractions are given in tables 3 and 4. The weight estimates for each fuel size

class are calculated by multiplying the total crown weight for harvested trees in each d.b.h. class (step 2b) by the fraction shown in the appropriate table. For the example described, the weight of crowns from the 5-inch d.b.h. class estimated in step 2b—1.3 tons per acre—is multiplied by 0.11—the foliage fraction for a 5-inch tree with a 50 percent crown ratio (table 4). The result is 0.14 tons per acre. Similar values are determined for each fuel size class and d.b.h.

D.b.h.	Tons/acre by d.b.h.	Fuel size class (inches)				
		Foliage	0-1/4	1/4-1	1-3	3+
		tons per acre				
5	1.3	0.14	0.05	0.14	0.35	0.61
6	1.4	.21	.07	.22	.39	.50
7	1.6	.27	.10	.32	.46	.45
		0.62	0.22	0.68	1.20	1.56

SUMMARY

These tables can be used by forest managers to obtain total estimates of crown weight and weight of crown components for shortleaf pine. The weights can be used for estimating material available for other forest products, predicting fire behavior potential for various cutting options, estimating smoke emissions for prescribed burns, and making fuel management decisions.

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Table 1.—*Weight per shortleaf pine tree—total crown and unmerchantable tip to a 3-inch top. (Weights above th dashed line are total tree weights, including the stem)*

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
	Pounds						
1	2	2	2	2	2	2	2
2	7	8	8	9	9	9	9
3	19	20	21	22	23	25	26
4	17	19	21	23	26	29	31
5	17	21	24	28	33	38	41
6	18	23	29	36	42	50	57
7	21	28	37	46	56	67	78
8	24	35	47	60	74	89	104
9	29	43	59	78	96	116	136
10	35	53	75	98	123	150	176
11	42	66	93	124	155	190	227
12	51	81	115	154	196	239	285
13	60	98	142	189	242	295	354
14	72	119	172	232	295	361	
15	85	142	207	279	357	439	

Table 2.—*Weight per shortleaf pine tree—total crown and unmerchantable tip to a 4-inch top.*

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
	Pounds						
5	42	46	49	53	58	63	66
6	38	44	49	57	63	70	74
7	39	46	55	64	73	86	97
8	40	51	63	76	90	105	121
9	43	58	73	93	111	130	151
10	48	68	88	111	136	163	191
11	53	78	105	136	167	202	239
12	62	92	126	165	207	250	296
13	75	108	152	199	252	305	364
14	82	129	182	242	305	371	
15	95	152	217	289	367	449	

Table 3.—*Crown component fractions for shortleaf pine by fuel size classes, including tip to a 3-inch merchantable top. Note that 1- to 3-inch material above dashed line includes stem*

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
	FOLIAGE						
1-2	0.12	0.12	0.17	0.21	0.21	0.25	0.27
3	.05	.07	.09	.10	.12	.13	.14
4	.10	.13	.16	.18	.19	.20	.20
5	.15	.18	.20	.21	.22	.22	.23
6	.19	.22	.23	.23	.24	.24	.23
7	.22	.24	.24	.24	.23	.24	.23
8	.24	.24	.26	.24	.23	.22	.22
9	.25	.26	.24	.23	.22	.21	.21
10	.26	.24	.24	.23	.21	.20	.19
11	.26	.24	.23	.21	.20	.19	.18
12	.25	.23	.22	.20	.20	.18	.17
13	.25	.22	.21	.19	.18	.17	.16
14	.24	.22	.20	.19	.17	.16	
15	.23	.21	.19	.18	.17	.15	
	0- TO 1/4-INCH BRANCHWOOD						
1-2	0.01	0.01	0.01	0.04	0.04	0.04	0.06
3	.02	.03	.03	.04	.04	.05	.05
4	.04	.05	.06	.06	.07	.07	.07
5	.05	.07	.07	.07	.07	.07	.08
6	.07	.08	.08	.08	.08	.08	.08
7	.08	.08	.08	.08	.09	.09	.09
8	.08	.08	.09	.09	.09	.09	.08
9	.08	.09	.09	.09	.09	.09	.08
10	.09	.09	.09	.08	.09	.08	.08
11	.09	.09	.09	.08	.08	.08	.08
12	.09	.09	.09	.08	.08	.08	.07
13	.09	.09	.08	.08	.07	.07	.06
14	.09	.08	.08	.08	.07	.07	
15	.09	.08	.07	.07	.07	.06	
	1/4- TO 1-INCH BRANCHWOOD						
1-2	0.44	0.44	0.42	0.40	0.40	0.38	0.38
3	.05	.06	.07	.08	.10	.11	.12
4	.08	.10	.13	.15	.17	.19	.21
5	.12	.15	.18	.21	.24	.25	.25

(Table 3 continued on next page)

(Table 3 continued)

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
6	.16	.21	.24	.26	.26	.26	.26
7	.20	.25	.27	.27	.27	.26	.25
8	.24	.28	.27	.27	.26	.25	.23
9	.27	.28	.28	.26	.24	.22	.20
10	.28	.28	.26	.23	.21	.20	.19
11	.29	.27	.24	.22	.19	.18	.18
12	.28	.25	.22	.19	.18	.18	.16
13	.28	.24	.20	.18	.17	.16	.15
14	.26	.22	.19	.18	.16	.15	
15	.25	.20	.18	.16	.15	.14	
1- TO 3-INCH BRANCHWOOD							
1-2	0.43	0.43	0.40	0.35	0.35	0.33	0.29
3	.53	.51	.49	.48	.46	.45	.43
4	.78	.72	.65	.61	.57	.54	.52
5	.68	.60	.55	.51	.47	.46	.44
6	.58	.49	.45	.43	.42	.42	.43
7	.50	.43	.41	.41	.41	.41	.43
8	.44	.40	.38	.40	.42	.44	.47
9	.40	.37	.39	.42	.45	.48	.51
10	.37	.39	.41	.46	.49	.52	.54
11	.36	.40	.44	.49	.53	.54	.53
12	.38	.43	.47	.53	.54	.53	.53
13	.38	.45	.51	.54	.54	.53	.49
14	.41	.48	.53	.52	.53	.48	
15	.43	.51	.54	.53	.48	.39	
>3-INCH BRANCHWOOD							
3	0.35	0.33	0.32	0.30	0.28	0.26	0.26
4							
5							
6							
7							
8							
9							
10							
11						.01	.03
12						.03	.07
13				.01	.04	.07	.14
14				.03	.07	.14	
15			.02	.06	.13	.26	

Table 4.—*Crown component fractions for shortleaf pine by fuel size classes, including tip to a 4-inch merchantable top*

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
	FOLIAGE						
5	0.06	0.08	0.10	0.11	0.13	0.13	0.14
6	.09	.12	.14	.15	.16	.17	.18
7	.12	.14	.16	.17	.18	.19	.19
8	.15	.17	.19	.19	.19	.19	.19
9	.17	.19	.19	.19	.19	.19	.19
10	.19	.20	.20	.20	.19	.19	.18
11	.21	.20	.20	.19	.19	.18	.18
12	.21	.21	.20	.19	.19	.17	.17
13	.20	.20	.19	.19	.17	.17	.16
14	.21	.20	.19	.18	.17	.16	
15	.21	.20	.18	.17	.16	.15	
	0- TO 1/4-INCH BRANCHWOOD						
5	0.02	0.03	0.03	0.04	0.04	0.04	0.05
6	.03	.04	.04	.05	.05	.06	.06
7	.04	.05	.06	.06	.07	.07	.08
8	.05	.06	.06	.07	.07	.07	.07
9	.05	.07	.07	.08	.08	.08	.07
10	.06	.07	.07	.07	.08	.07	.07
11	.06	.08	.08	.08	.07	.07	.07
12	.07	.08	.08	.07	.07	.07	.07
13	.07	.08	.08	.08	.07	.07	.06
14	.08	.08	.07	.07	.07	.06	
15	.08	.08	.07	.07	.07	.06	
	1/4- TO 1-INCH BRANCHWOOD						
5	0.05	0.07	0.09	0.11	0.13	0.15	0.16
6	.08	.11	.14	.16	.18	.18	.20
7	.11	.15	.18	.20	.20	.20	.21
8	.14	.19	.20	.22	.22	.21	.20
9	.18	.21	.22	.22	.21	.19	.18
10	.20	.22	.22	.21	.19	.18	.17
11	.22	.23	.21	.20	.18	.17	.17
12	.23	.22	.20	.18	.17	.17	.16
13	.22	.22	.19	.17	.17	.16	.14
14	.23	.20	.18	.17	.16	.15	
15	.23	.19	.17	.16	.14	.13	

(Table 4 continued on next page)

(Table 4 continued)

D.b.h. (inches)	Crown ratio (percent)						
	20	30	40	50	60	70	80
	1- TO 3-INCH BRANCHWOOD						
5	0.28	0.27	0.27	0.27	0.27	0.28	0.27
6	.27	.27	.27	.28	.28	.31	.29
7	.27	.27	.27	.29	.31	.33	.34
8	.27	.27	.29	.31	.34	.38	.41
9	.26	.28	.32	.35	.39	.43	.46
10	.27	.31	.35	.40	.44	.48	.51
11	.29	.34	.40	.44	.49	.51	.51
12	.31	.38	.43	.49	.51	.51	.51
13	.37	.40	.47	.51	.51	.51	.49
14	.35	.44	.50	.51	.50	.47	
15	.38	.47	.52	.51	.47	.39	
	> 3-INCH BRANCHWOOD						
5	0.59	0.55	0.51	0.47	0.43	0.40	0.38
6	.53	.46	.41	.36	.33	.28	.27
7	.46	.39	.33	.28	.24	.21	.18
8	.39	.31	.26	.21	.18	.15	.13
9	.34	.25	.20	.16	.13	.11	.10
10	.28	.20	.16	.12	.10	.08	.07
11	.22	.15	.11	.09	.07	.07	.07
12	.18	.11	.09	.07	.06	.08	.09
13	.14	.10	.07	.05	.08	.09	.15
14	.13	.08	.06	.07	.10	.16	
15	.10	.06	.06	.09	.16	.27	

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The tables provided here estimate crown weights of shortleaf pine (*Pinus echinata* Mill.) from measurements of diameter (d.b.h.) and crown ratio, for both a 3-inch and a 4-inch merchantable top. Crown component fractions for standard fuel size classes are also presented.

Key Words: Fuel management, debris prediction, *Pinus echinata*

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